State of California
AIR RESOURCES BOARD

Staff Report: Initial Statement of Reasons for Proposed Rulemaking

Public Hearing to Consider the Adoption of a Regulatory Amendment Identifying Chlorinated Dioxins and Dibenzofurans as Toxic Air Contaminants

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(This report has been reviewed by the staffs of the California Air Resources Board and the California Department of Health Services and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Air Resources Board or the Department of Health Services, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.)

OVERVIEW AND RECOMMENDATION

I. INTRODUCTION

The Air Resources Board (“ARB” or "Board") identifies toxic air contaminants and develops regulations for the control of their emissions according to the requirements of state law. A toxic air contaminant (TAC) is an air pollutant that the Board or the Department of Food and Agriculture finds may cause or contribute to an increase in mortality or an increase in serious illness, or which may pose a present or potential hazard to human health. This report recommends that the Board find dibenzo-p-dioxins and dibenzofurans chlorinated in the 2,3,7, and 8 positions which contain four, five, six, or seven, chlorine atoms to be toxic air contaminants (Table 1).

This group of cholorinated dioxins and dibenzofurans was selected for identification as toxic air contaminants because many chlorinated dioxins and dibenzofurans have been demonstrated to be carcinogens or have the potential to be carcinogens. Also, a wide variety of chlorinated dioxins and dibenzofurans chemical species have been observed in emissions from certain classes of combustion sources. The potency of chlorinated dioxins and dibenzofurans is dependent on the chemical structure of the individual chlorinated dioxin or dibenzofuran compound. The toxicity of various tetrachlorodioxins, for example, may vary by a factor of 100,000 or more.

"Dioxin" is a generic term used to denote any of a family of compounds which are derived from dibenzo-p-dioxin, or a mixture of such compounds. The basic structure of all dioxins consists of two benzene rings joined to each other by two oxygen atoms (I). A closely related family of compounds are the dibenzofurans (II). They have structures and properties similar to dioxins and are often found in association with them. A dioxin or dibenzofuran is

TABLE 1

CHLORINATED DIOXINS AND DIBENZOFURANS OF CONCERN

	Dioxins	**Dibenzofurans**
Tetrachloro	2,3,7,8	2,3,7,8
Pentachloro	1,2,3,7,8	1,2,3,7,8 2,3,4,7,8
Hexachloro	1,2,3,4,7,8 1,2,3,6,7,8 1,2,3,7,8,9	1,2,3,4,7,8 1,2,3,6,7,8 1,2,3,7,8,9 2,3,4,6,7,8
Heptachloro	1,2,3,4,6,7,8	1,2,3,4,6,7,8 1,2,3,4,7,8,9

NOTE: The numbers indicate the position of chlorine atoms on the dioxin or dibenzofuran molecule.

said to be “chlorinated” if a chlorine atom is attached to any of the sites labeled 1-4 and/or 6-9 on (I) or (II) respectively. Dioxins and dibenzofurans are classified into groups termed homologues on the basis of the number of chlorine atoms in the molecule. Thus tetrachloro-dibenzo-p-dioxins and dibenzofurans contain four chlorine atoms, pentachloro-dibenzo-p-dioxins and dibenzofurans contain five chlorine atoms, and so on. Within each homologue individual isomers are characterized by the location of the chlorine atoms on the rings.

DIOXIN **DIBENZOFURAN**

DIAGRAM GOES HERE

I II

There are 75 different polychlorinated dibenzo-p-dioxins and 135 polychlorinated dibenzofurans, differing from each other by the number and location of chlorine atoms on the molecule. This makes chemical analysis exceedingly difficult because environmental samples are composed of a complex mixture of a large number of various chlorinated dioxins and dibenzofurans at very low concentrations.

The Overview to the report presents the technical and toxicological information that supports the staff's recommendation and summarizes the regulatory background and reviews the procedures by which the Board considers substances for the TAC designation.

II. EVALUATION OF CHLORINATED DIOXINS AND DIBENZOFURANS

The ARB and the DHS prioritize candidate substances for evaluation and regulation as toxic air contaminants pursuant to Health and Safety Code Section 39660(f). That section states that the selection of a substance consideration as a TAC is to be based on the risk to the public posed by the substance, the amount or potential amount of emissions from use of the substance, its manner of usage in California, its atmospheric persistence, and its concentration in the ambient air.

A. EMISSIONS, PERSISTENCE, AND AMBIENT CONCENTRATIONS

Information about chlorinated dioxin and dibenzofuran sources is limited because these materials are unwanted trace contaminants of some chemical and combustion processes, are emitted in very small quantities, and have only been studied a relatively short period of time. Because there are so many unknowns with regard to chlorinated dioxins and dibenzofurans, the objective of evaluating these substances as toxic air contaminants is to place the risk posed by them into perspective and to develop a review process for potential sources. Many potential sources of chlorinated dioxins and dibenzofurans are being proposed for construction in California, and this review of the impacts of chlorinated dioxin and dibenzofuran emissions will be of particular value in the review of new facilities. Table 2 contains a list of potential chlorinated dioxin and dibenzofuran emission sources and a qualitative appraisal of the relative emission rates of sources of chlorinated dioxin and dibenzofurans. For example, municipal waste incinerators and refuse derived fuel (RDF) Boilers are expected to emit more chlorinated dioxins and dibenzofurans than cement kilns cofiring wastes.

TABLE 2

POTENTIAL CHLORINATED DIOXIN AND DIBENZOFURAN
SOURCE CATEGORIES IN CALIFORNIA

Source Category	Operational in Calif.	Proposed for Calif.	Estimate of Relative Emissions[1/]
Point Sources			
Municipal Waste Incinerators and RFD Boilers	1	35	High
Commercial Waste Oil Burners	30+	ND	Unknown
Hazardous Waste Incinerators	17	3	Low
Industrial Boilers Cofiring Wastes	0	0	Unknown
Wire Reclamation Incinerators	76[2/]	ND	Unknown
Sewage Sludge Incinerators	8	ND	Unknown
Wood/Bark Boilers	59	ND	High[3/]
Black Liquor Boilers	4	0	Unknown
PCP Sludge Incinerators	ND	ND	High
Cement Kilns Cofiring Wastes	1	1	Low
Hospital Incinerators	311[2/]	ND	Unknown
Sawmills[4/]	86	ND	High[3/]
Area Sources			
Mobile Sources	NA		Unknown
Wood Stove/Fireplaces	NA		Unknown
Forest Fire/Agricultural Burning	NA		Unknown

ND - no data

NA - not applicable

[1/] This is a qualitative assessment of the expected emissions relative to the other source categories listed.

[2/] Statewide number estimated from data supplied by San Diego Air Pollution Control District and the South Coast Air Quality Management District.

[3/] When burning wood treated with chlorophenol, otherwise these are rated as low.

[4/] Most sawmills have the capability to incinerate some or all of the woodwaste produced at the facility. A wood/bark boiler may be used at sawmill to incinerate process wastes. This source category may overlap other source categories listed in the table.

Chlorinated dioxins and dibenzofurans are highly persistent under normal environmental conditions, particularly when adsorbed on soils or other substrates. Long distance transport of these materials in the atmosphere has been documented. The half life of 2,3,7,8 TCDD has been reported to be approximately one year in soil, but may persist even after twelve years. Dioxins are degraded by sunlight in solution under laboratory conditions, the extent to which dioxins are degraded by sunlight in the atmosphere is unknown.

Emissions of chlorinated dioxins and dibenzofurans from combustion, sources into the atmosphere appears to be the major environmental source of dioxins, but few categories of potential sources of dioxins and dibenzofurans have been adequately tested. Municipal waste resource recovery facilities are the most studied source of chlorinated dioxins and dibenzofurans and the only source category sufficiently studied to estimate emission rates. One of these facilities is now in operation in the state, but over thirty are proposed for construction. Based on tests of municipal waste recovery facilities similar to the types expected to be built in California, we estimate that 18-308 pounds of chlorinated dioxins and 41-663 pounds of chlorinated dibenzofurans would be emitted in California annually if all currently proposed facilities are constructed.

The ARB has projected possible annual average ambient concentrations of chlorinated dioxins and dibenzofurans which might occur at specific locations in the Los Angeles area if several proposed solid waste incinerators were to begin operating. The ambient concentrations listed below were calculated using air quality modeling and show the maximum impact of several sources at a single location. The ambient concentrations listed below are chlorinated dioxins and dibenzofurans with four, five, six, seven or eight chlorine atoms.

	High Estimate	**Low Estimate**	**Best Estimate**
PCDDs	13 pg/m^3	0.7 pg/m^3	4.0 pg/m^3
PCDFs	27 pg/m^3	1.6 pg/m^3	8.2 pg/m^3

The upper-bound estimate of risk, calculated as the product of the annual average concentration range and the dose-response relationships given by the DHS, ranges between 2 and 38 excess cancers per million population exposed. Our best estimate of excess cancers within this range is 12 per million. These risk values represent only the risk due to inhalation exposure.

These ambient concentrations are in addition to any background levels already present from existing sources of chlorinated dioxins and dibenzofurans. Although there is currently no data available for ambient background concentrations in California, ambient chlorinated dioxin and dibenzofuran concentrations have been measured in samples collected in other urban areas of the United States. Extrapolation of these results to typical Los Angeles conditions suggest that the projected ambient concentrations due to emissions from the proposed solid waste incinerators will be of the same order or magnitude as Los Angeles background concentrations. The ARB plans to conduct a special monitoring study to determine existing chlorinated dioxin and dibenzofuran levels in the Los Angeles area in the near future.

Chlorinated dioxins and dibenzofurans adsorbed on airborne particulate are eventually deposited on the soil and water. This opens a secondary exposure route via ingestion and dermal exposure to contaminated particulates. Secondary exposure, due to such soil and water pollution, may be as significant as atmospheric exposure and could substantially increase the total public health risk of chlorinated dioxin and dibenzofuran emissions.

At this time, it is not possible to quantitatively assess the contribution of noninhalation exposure routes to total chlorinated dioxin and dibenzofuran exposure with any degree of confidence. Studies of the impacts of potential chlorinated dioxin and dibenzofuran sources indicate that contribution from the ingestion and dermal exposure routes will increase total chlorinated dioxin and dibenzofuran exposure above that calculated for

inhalation alone. Future research work is needed to determine the magnitude of the contribution from these exposure routes.

B. HEALTH EFFECTS AND RISK

In response to the ARB staff's request and according to Health and Safety Code Section 39660, the Department of Health Services (DHS) evaluated the health effects of chlorinated dioxins and dibenzofurans and the risks from exposure to chlorinated dioxins and dibenzofurans. To ensure satisfaction of the requirement in HSC for the consideration of all pertinent information, we provided DHS with a bibliography of literature concerning the health effects of chlorinated dioxins and dibenzofurans. The bibliography (included in Part A) was obtained from the MEDLARS II and DIALOG data bases. Also, we sent a letter (included in Part A) to interested parties to request additional information. The information so obtained was forwarded to DHS.

The DHS' draft report (Part B) along with Part A were released to the public for comment. The comments received are included in Part C. The revised Part A & B were presented to the Scientific Review Panel after consideration of those comments.

In meeting the requirements in Section 39660 for DHS' evaluation, the DHS addresses these questions in Part B: l) Are chlorinated dioxins and dibenzofurans carcinogens in animals? 2) Should chlorinated dioxins and dibenzofurans be considered carcinogens in humans? 3) May health problems other than cancer occur from exposure to anticipated ambient concentrations? 4) Is there an exposure level below which chlorinated dioxins and dibenzofurans will not cause cancer? 5) What is the most appropriate model to perform low-dose extrapolation to estimate the risk of chlorinated dioxins and dibenzofurans at ambient concentrations and what is the range of extrapolation? 6) What is the range of added risk of cancer during a lifetime of exposure to anticipated ambient

concentrations of chlorinated dioxins and dibenzofurans? In response to these questions, the DHS concludes (in paraphrase of the conclusions in Part B) that:

- 2,3,7,8 TCDD and the mixture of hexachlorodioxins tested are carcinogenic in animals;

- Dioxins and dibenzofurans chlorinated in the 2,3,7, and 8 positions which contain four five, six, or seven chlorine atoms are potential human carcinogens;

- Health effects other than cancer are not expected to occur at projected ambient levels;

- There is not sufficient scientific evidence to support the identification of an exposure level below which carcinogenic effects would not occur;

- The multistage model has the best biological basis for extrapolating the response observed in an animal bioassay to the expected risk at ambient concentrations, and the low-dose extrapolation is over a range of up to ll,O00-fold; and

- The maximum likelihood estimate of lifetime excess cancers is 240 per million for continuous exposure to 2,3,7,8 TCDD at an airborne concentration of 10 pg/m^3 and 6-10 per million for comparable exposure to the hexachlorodioxins tested.

Chlorinated dioxins and dibenzofurans, most of which have never been tested for carcinogenicity, are emitted into the air from combustion sources as a mixture. Furthermore, the composition of this mixture may vary depending upon the emission source. In order to estimate a range of risks that might result from such ambient air mixtures, the DHS makes different assumptions about the concentrations of the various

chlorinated dioxin and dibenzofuran species present in the total mixture, and the relative carcinogenic potencies of the chlorinated dioxins and dibenzofurans that have not been tested for carcinogenicity. The result is an estimated "TCDD equivalent concentration," which allows the conversion of exposure to the mixture of chlorinated dioxin and dibenzofurans emitted to a like exposure to 2,3,7,8-TCDD.

DHS has decided for the purposes of this document, that dioxins and dibenzofurans with one, two, three, or eight chlorines are relatively nontoxic. This is based on the fact that in the small number of toxicology studies on these compounds, they are consistently much less potent than many of the other dioxins and dibenzofurans.

Additionally, DHS concluded that there is not sufficient evidence to support the identification of an exposure level below which carcinogenic effects would not occur. DHS guidelines for risk assessment, as Outlined in Guidelines for Chemical Carcinogen Risk Assessments and Their Scientific Rationale, do not recommend the use of thresholds for carcinogenesis unless clear and convincing evidence is presented to demonstrate their existence for a specific carcinogen in specified circumstances. DHS staff and the U.S. Environmental Protection Agency have concluded that convincing evidence of a threshold does not exist at this time and that there is no exposure level below which carcinogenic effects from chlorinated dioxins and dibenzofurans would not be expected to occur.

Before reaching this conclusion, DHS considered the fact that the Ontario Ministry of the Environment has established an acceptable daily intake level (ADI) for 2, 3, 7, 8 TCDD. DHS staff reviewed the studies used by Ontario Ministry of the Environmental in establishing the ADI. However, DHS staff has concluded that while this approach would protect against threshold-mediated outcomes such as reproductive toxicity and

immunotoxicity, it may not be protective against carcinogenesis and could result in higher individual incremental lifetime cancer risks (see pages 1-3 through 5 and 9-1 through 4 of Part B of this report).

III. REGULATORY BACKGROUND AND PROCEDURES

Division 26, Chapter 3.5 of the Health and Safety Code (HSC)* and Food and Agriculture Section 14021 et seq. sets forth the procedure for identifying and controlling toxic air contaminants in California. (These provisions were enacted in September 1983 as Assembly Bill 1807, Stats. 1983, ch. 1047; see Part C of this report.) The Department of Food and Agriculture is responsible for identifying and controlling TACs in their pesticidal uses. The ARB has authority over TACs in all their other uses.

HSC Section 39650 sets forth the Legislature's findings about substances which may be TACs. The Legislature has declared:

> "That public health, safety, and welfare may be endangered by the emission into the ambient air of substances which are determined to be carcinogenic, teratogenic, mutagenic, or otherwise toxic or injurious to humans."

The findings also include directives on the consideration of scientific evidence and the basis for regulatory action. With respect to the control of TACs, the Legislature has declared:

> "That it is the public policy of this state that emissions of toxic air contaminants should be controlled to levels which prevent harm to the public health."

The Legislature has further declared that, "while absolute and undisputed scientific evidence may not be available to determine the exact nature and extent of risk from toxic air contaminants, it is necessary to take action to protect public health."

In the evaluation of substances, the Legislature has declared that the best available scientific evidence, gathered from both public agencies and private sources including industry, should be used. The Legislature has also determined that this information should be reviewed by a scientific review panel and by the public.

The Board's determination of whether or not a substance is a toxic air contaminant includes several steps specified by the HSC. First, ARB staff requests that DHS evaluate the health effects of a substance (Section 39660). The evaluation includes a comprehensive review of all available scientific data. Upon receipt of a report on health effects from DHS and in consideration of their recommendations, ARB staff prepares and submit a report to the Scientific Review Panel (SRP) for its review (Section 39661). The report consists of the DHS report (Part B), material prepared by the ARB staff on the use, emissions and ambient concentrations of the substance (Part A), and various supporting documents in Part C. It serves as the basis for future regulatory action by the Board. The report is also made available to the public, which may submit comments on the report to the SRP.

After receiving the SRP's written findings on the report, the Board issues a public hearing notice and a proposed regulation stating whether or not the substance is a toxic air contaminant. If, after a public hearing and other procedures to comply with Government Code Section 11340 et seq., the Board determines that a substance is a toxic air contaminant, its findings must be set forth in a regulation (Section 39662). The HSC also sets forth procedures for developing and adopting control measures for substances identified as TACs (Sections 39665-39667).

IV. ENVIRONMENTAL EFFECTS

The identification of chlorinated dioxins and dibenzofurans as TACs will not in itself have any environmental effects. If the Board lists chlorinated dioxins and dibenzofurans as TACs, the staffs of the ARB and the air pollution control districts will evaluate the need for, and appropriate degree of controls for emission sources. After this evaluation, the Board and the districts may adopt emission control measures which will result in the reduction of chlorinated dioxins and dibenzofurans in the ambient air. Any environmental effects associated with control measures will be identified when such control measures are considered pursuant to HSC Sections 39665 and 39666.

V. RECOMMENDATION

Because some chlorinated dioxins and dibenzofurans are known animal carcinogens and all chlorinated dioxins and dibenzofurans chlorinated in the 2,3,7,and 8 positions which contain 4,5,6, or 7 chlorine atoms were found to be potential human and animal carcinogens with a high potential for emissions in California, the ARB staff recommends their listing as toxic air contaminants. In making this recommendation, we note that there is not sufficient available scientific evidence to support the identification of an exposure level below which carcinogenic effects would not occur.